DOCUMENT RESUME

ED 236 110 SP 022 511

AUTHOR Markle, Sandra
TITLE Natural Wonder Notebook. [Five Installments of a Monthly Column Appearing in Instructor Magazine, January-May 1983.]
INSTITUTION ERIC Clearinghouse on Teacher Education, Washington, D.C.
PUB DATE 83
NOTE 14p.; Miniposters are not included.
PUB TYPE Journal Articles (080) -- Guides - Classroom Use - Guides (For Teachers) (052)
JOURNAL CIT Instructor; v92 n5-9 Jan-May 1983

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Discussion (Teaching Technique); Elementary Education; Elementary School Science; Learning Activities; *Natural Sciences; *Science Activities; Writing Exercises
IDENTIFIERS PF Project

ABSTRACT

This science column includes background information, discussion questions, science activities, writing activities, and a bibliography on a different topic each month. The titles of the five installments included in this compilation are: (1) "Chameleons and Other Quick-Change Artists"; (2) "Niagara Falls and Other Super Waterfalls"; (3) "Elephants' Trunks and Other Nifty Sniffers"; (4) "Tornadoes and Other Big Winds"; and (5) "The Grand Canyon and Other Holes in the Ground." (DC)

NATURAL WONDER NOTEBOOK

[FIVE INSTALLMENTS OF A MONTHLY COLUMN APPEARING IN INSTRUCTOR MAGAZINE, JANUARY-MAY 1983.]

by Sandra Markle

Compiled by
The ERIC Clearinghouse on Teacher Education
Washington, DC

Chameleons
and other quick-change artists

Sandra Markle

Leapin' Lizards! One moment it's brown and the next lime green! The fellow known as the chameleon is just doing what comes naturally—exhibiting the natural phenomenon of changing its skin color. The chameleon isn't the only one whose skin color changes; humans, for instance, occasionally have found their faces turning colors, much to their embarrassment!

This month INSTRUCTOR *begins a regular science feature called Natural Wonder Notebook. Its first in a series of monthly investigations into nature focuses on the phenomenon of changing skin color. Science consultant Sandra Markle will explore why this phenomenon occurs, and she will tell you more about those in the animal kingdom who are able to make this "quick change."*

Accompanying this basic information is a colorful miniposter to display and a list of activities Sandra suggests you use with your students. "The activities are really exercises in good thinking," she says. The first section, Let's Talk, *is a collection of discussion questions that lead students to inquire and hypothesize about color changes in skin. The second section,* Let's Investigate, *has each student make his or her own paper chameleon and simulate the color changes it experiences. The final section,* Let's Write, *encourages children to organize the results of their discussion and experiments into effective forms of writing. Sandra believes that "when students are asked to talk over, investigate, and finally write about, a scientific phenomenon, they really begin to learn what it's all about."*

You may want to expand the study of color change by having kids make a Natural Wonder Corner in your room, complete with books, posters, and bulletin boards on the subject. (You might even enlarge an encyclopedia diagram showing the chameleon's skin layers of various pigments.) Enlist your media specialist's help in finding other materials and check the bibliography at the end of this feature.

When the month's over, store your miniposter and activity information in a spiral notebook for easy reference. Then prime your students for February's feature—and a new corner—on Niagara Falls. The feature's general setup will be the same—a miniposter plus interesting facts and activities that encourage talking, experimenting, and writing. Wonders to come in months ahead include elephants' trunks and other nifty sniffers, tornadoes, and the Grand Canyon! This series will convince your kids that natural wonders are even more wonderful when they get to know them.

The picture of the green lizard on the left may well be a picture of an angry chameleon. Or it may be that the colorful fellow has just seen a heron fly over and has been frightened green by its enemy. At any rate, chances are the chameleon was another color—maybe brown or gray—at least once earlier in the day. Chameleons are quick-change artists, all right, but they don't just change color any time they want to.

Factors that affect a chameleon's involuntary color change are temperature, sunlight, nervous stimulation (fear, anger, hunger), and the chameleon's own pigmentation. In the morning when the air is cool and there is little sunlight, your typical lizard might start its day off a spotted, light brown shade. As the day becomes warmer and brighter, the chameleon may turn solid gray brown, making it easier to blend into its environment and sneak up on tasty insects. The chameleon moves very slowly but can do two things fast—change colors (in 90 seconds) and whisk its lengthy tongue out to snatch its prey (in one-third second).

A chameleon meeting an oncoming chameleon may issue a color threat. Puffed up and bulging, the angry chameleon may display yellow stripes or turn vivid green, even when its surroundings are not. A fight usually ensues; the winner will always be a brighter color than the loser.

The chameleon also changes color to startle its predator, giving itself time to get away. And during courtship, chameleons display a whole range of colors—from yellow, white, and various shades of green to brown and even brick red.

To get an idea of what *enables* a chameleon to change colors, you must know about its skin layers and pigmentation. For a better understanding, hold out one hand and spread your fingers apart. Now put the other hand directly under this one, spread the fingers and turn your lower hand so the top and bottom fingers cross, forming a grid. Think of the top hand as a layer of skin containing only blue pigment cells. The lower hand is a skin layer of yellow cells.

Below your two hands, picture saclike cells which have long tendrils extending up through the space between your fingers (which is like space between tissue cells) and embedding in the top layer of blue cells. These saclike cells are *melanophores*, containing tiny granules of dark pigment.

Sometimes a chameleon's granules will collect in the cell sacs so tightly that they won't change the lizard's skin color at all. That's when you see the yellow and blue layers of skin close together. The effect is green. (The sensations of anger or fear might be causing the chameleon's granules to bunch together.)

Sometimes the granules will spread out in the cell sac only. The effect is brownish green. (The light, temperature, and moisture as well as a placid mood may be the causes.)

Sometimes the granules may spread into one or more tendrils and mask some or most of the yellow color in the lower skin layer, resulting in shades of bluish brown, brown, black, or stripes and spots.

Also, in the chameleon, red cells move throughout the skin layers, sometimes adding still other effects.

Other color-changers

Chameleons are not the only animals that change color. The octopus is another quick-change artist. Normally a dull shade of gray, a frightened, angry, or excited oc-

topus may turn a deep rose, orange, red, or purple. Small bags of pigment cells in the animal's skin are connected to its nervous system. The bags expand or contract, depending on the octopus's emotional state. Changing to a bright color startles predators and allows an octopus to make a quick getaway.

The flounder is another color-changer. This saltwater flatfish lives on the bottoms of bays and along the shores of most seas. It has a flattened body with an underside that is almost white. By reflecting light, the flounder's upper side changes color to match the bottom of the sea or bay. This enables it to lie unseen by the shrimp and small fish it captures for food.

Let's talk

1. Think about the chameleon and the flounder. Why is color change important to them? (Color changes enable them to blend into the environment. This helps them hide from enemies and ambush victims for food. In some cases, bright color changes in the chameleon are important for courtship because they attract mates.)
2. The squid is a sea animal that is similar to the octopus. Like the octopus, when a squid is frightened, it turns a bright shade of red. Why is this a good color to turn? (The sudden brightness startles predators and allows the octopus or squid to make a quick escape.)
3. The hippolyte is a small relative of the shrimp. A very young hippolyte can turn green, brown, violet, yellow, orange, or red within a 10-minute period. But an adult hippolyte is likely to require 24 hours to complete a color change. Why are the adults so much slower? (Young hippolytes get more practice! Adults are larger and better able to defend themselves from predators without having to change color.)
4. What if your own skin could change color with your moods? What color would you become to express anger? Sadness? Happiness? Boredom? (Answers will vary.)

Let's investigate

1. Students can make their own paper chameleons and explore how this animal makes quick color changes. First, have each student draw a chameleon on black construction paper and cut it out. The shape should include key features like turret eyes, a prehensile (handlike) tail, and gripping legs. Next, cut an oval in the middle of the body. Give each student a piece of yellow, red, green, blue, and black tissue, each large enough to cover the oval.

Now, for a quick change, tell students to paperclip different combinations of tissues over the body opening. They can see how different-colored tissues mix to form other shades, tones, or colors.

Let's write

1. Pet-store owners often confuse the chameleon with another small lizard, called the *anole*. They are closely related, but there are important differences between them. Use reference books to find out how they are alike and how they differ. In a short report, explain how a pet owner could tell a chameleon from an anole. (The anole moves much faster than the chameleon and has a longer, more slender body. Also, chameleons cling to tree branches with their tails, while anoles use their sticky footpads.)
2. The fiddler crab is another color-changer. Use reference books to find out what colors this animal displays and under what conditions. Then write a diary entry about a day in the life of a fiddler crab. Mention at least three different events that caused color changes. (Fiddler crabs are red when excited or frightened, dark reddish brown with purple hues when angry, and light brown under normal conditions.)
3. When you blush, your face undergoes a quick color change. Find out what happens in your body to cause this? (Blushing results from stimulation of the vasodilator nerves, located in tiny blood vessels near the surface of the skin, known as *capillaries*. When the vasodilator nerves are stimulated, they cause the capillaries to swell with blood. As a result, your face reddens and becomes warm.)

Now describe something that happened to you which really made you blush!

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Sandra Markle is INSTRUCTOR's science consultant. She teaches science in the classroom and on TV.

Niagara Falls
and other super waterfalls

Sandra Markle

Is it true that Niagara Falls is shrinking? What makes a waterfall fall? In this month's Natural Wonder Notebook, science consultant Sandra Markle will explore the answers to these and other mysteries about powerful waterfalls. Also included are brain-stretching discussion questions, an activity that simulates how Niagara Falls was formed, and three challenging writing assignments. Sandra believes that "when students are asked to talk over, investigate, and then write on a scientific phenomenon, they really begin to learn what it's all about."

You may want to expand your study of waterfalls by having kids set up a Natural Wonder Corner in your room, complete with magazines, posters, and bulletin boards. Start by clipping and posting the miniposter of Niagara's Horseshoe Falls at left. Enlist your librarian or media specialist's help in finding other materials and check the bibliography at the end of this feature.

When the month's over, store your miniposter and activity information in a ringed notebook for easy reference. Then prime your students for March's feature—and a new corner—on elephants' trunks and other nifty sniffers! This series will convince your kids that natural wonders are even more wonderful when you begin to explore them.

Each second during the day, 700,000 gallons of water plunge over the rim of Niagara Falls. That's enough water to wash 23,333 loads of clothes, fill 4,000 bathtubs, or flush 140,000 toilets! These thundering waters form the most powerful falls in the United States and the third mightiest in the world.

Why Niagara falls

Some waterfalls are formed overnight. For example, during an earthquake in 1959, plates in the earth shifted and caused the land around Hegben Lake in Montana to drop sharply. Now, previously smooth-running streams pour down several rocky waterfalls.

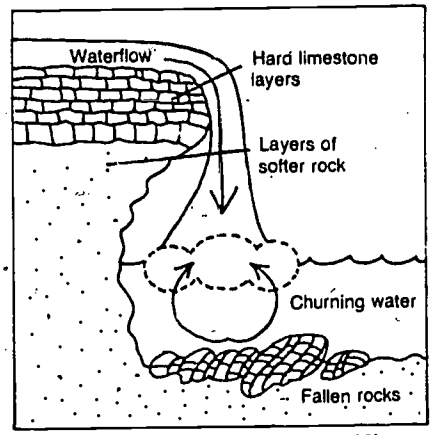
Other falls, like Niagara, were created through centuries of erosion. About 12,000 years ago when the last ice age ended, a melting ice sheet caused Lake Erie to overflow. The overflow formed the Niagara River, which began to run north toward Lake Ontario. The force of its moving water and the scouring action of the gravel that was carried with it widened and deepened the river channel. But then the river reached an area of land made of hard dolimite rock (compact limestone). This rock cap was 80 feet thick and virtually erosion-resistant, and so the river flowed over the rock cap without cutting through much rock.

Beyond the cap, however, the land was made of soft layers of limestone, sandstone, and shale, and so once again the river was able to erode the earth. Eventually, the river's activity formed a steep, canyonlike gorge with the rock cap as the gorge's highest point and the bed of softer earth below it sinking lower and lower. That gorge became Niagara Falls. Today Niagara Falls forms a boundary line for Canada and the United States.

Breaking away

Niagara is actually two falls separated by Goat Island. The crescent-shaped Horseshoe Falls (on the Canadian side) is 185 feet high and 2,600 feet wide. The American Falls (on the U.S. side) is 190 feet high and about 1,000 feet wide. Rock slides gradually have changed the appearance of Niagara Falls through the years. Churning waters at the base of the falls eat away the soft underlying rock layers, causing the unsupported hard rock on top to break off. (See diagram.) Most of this erosion occurs on Horseshoe Falls because more than 90 percent of the Niagara River plunges over it. On the average, Horseshoe Falls shrinks back toward Lake Erie at a rate of about three feet each year. The American Falls loses four to six inches a year.

Because Niagara Falls is an important source of hydroelectric power and because it's a tourist attraction, in the 1960s, people became concerned about the crumbling rock cap. In 1969, the Army Corps of Engineers built a dam to temporarily shut off the American Falls. Workers then cemented seriously eroding areas on the falls. During the project, the engineers were able to estimate the amount of money and effort it would take to make a major reinforcement of the falls and decided it would be too expensive.



So if you're planning to see Niagara Falls, don't wait too long. Waterfalls don't last forever. Geologists estimate that Niagara will probably only fall for another 22,800 years.

Falling power

Hydroelectric stations use the force of moving water to produce electricity. There are three such stations at Niagara Falls. One is the Robert Moses plant, which is the largest hydroelectric generating station in the eastern United States and one of the largest in the world. The two Sir Adam Beck plants on the Canadian side are smaller but also use the falls to produce a great deal of electricity.

A treaty between the United States and Canada stipulates that 100,000 cubic feet of water would be allowed to flow over the falls in the daytime and 50,000 cubic feet could flow at night. This water is for people to watch. Before the rest of the water reaches the falls, it is directed through descending tunnels and canals that eventually lead to turbines. The moving

water turns the turbines, which turn generators which produce electricity.

Other super falls

At an average height of 182 feet, Niagara is not tall compared to other falls. But the amount of water that pours over it makes it a powerful one. It is a drainage outlet for the four upper Great Lakes—Superior, Michigan, Huron, and Erie. And more than a million springs pour into those lakes!

For information on other powerful falls, see the chart at the bottom of this page. Angel Falls (2,648 feet) in Venezuela is the highest waterfall in the world, and Ribbon Falls (1,612 feet) in California is the highest waterfall in the United States, but neither has water flows as powerful as the falls in the chart.

Let's talk

1. American Indians lived in the Niagara Falls area long before the first Europeans arrived. The name *Niagara* comes from the Iroquois word *Onguiaahra* meaning the strait. Why is Niagara a good name for this falls and river? *(A strait is a narrow passageway that connects two large bodies of water. Niagara Falls and the Niagara River are situated between Lakes Erie and Ontario.)*

2. Explain why there is often a rainbow over Niagara and other waterfalls. How could you make your own rainbow? Hint: Start by finding out what causes rainbows. Check reference books. *(When light passes through water, it refracts—bends. When this happens, it spreads out the different colors that make a light ray. Spraying water into sunlight will create the same effect as a rainbow above Niagara Falls.)*

3. Why are only a few of the world's biggest falls used to generate hydroelectric power? *(Most of the world's biggest falls are located in rough, inaccessible areas that make the construction of a generating station difficult. Also, some of the highest falls don't have as much water flow as some of the lower falls. Heavy water flow is needed for hydroelectric power.)*

Let's investigate

1. Your students can see for themselves how Niagara Falls was formed. Divide them into teams of five or six students. Give each team a fairly large cardboard box, a bag of garden soil, and a three- to four-inch piece of foam meat tray.

First, have students pack down a two-inch layer of dirt, then another two-inch layer, and another. Now place the piece of meat tray on the dirt, about four inches from one end of the box. Pack down another two inches of soil.

Starting from the end of the box where the meat tray is buried, tell students to use their fingers, a pencil, or a spoon to imitate the movement of rapidly flowing water and carve a river channel. (Do not use water to do this. It will destroy the box.) The river can curve and meander from one side to the other, cutting deeper and deeper into the earth. When kids reach the foam chunk, they should leave the channel at the level of the chunk. Past the chunk, they should continue to dig the channel deeper.

Gradually, the waterfall will take shape. Encourage students to erode layers of soft soil that lie under the resistant foam layer, just the way churning water at the bottom of Niagara Falls does. Children should even break off pieces of foam to demonstrate how Niagara Falls is slowly retreating.

Let's write

1. Louis Hennepin, a Roman Catholic priest who traveled with the French explorer Robert de La Salle, left us the first written account of Niagara Falls. In a book

Powerful waterfalls

Waterfall	River	Average Water Flow Over the Falls	Average Height
Guairá	Parana (Brazil-Paraguay)	470 cubic ft. per sec.	213 ft.
Knone	Mekong (Cambodia-Laos)	410 cubic ft. per sec.	70 ft.
Niagara	Niagara (Canada-United States)	212 cubic ft. per sec.	182 ft.
Grande	Uruguay (Argentina-Uruguay)	106 cubic ft. per sec.	75 ft.

published in 1683, he wrote: "These waters foam and boil in a fearful manner. They thunder continually." It's been 300 years since Hennepin viewed Niagara Falls. He probably would appreciate an update from you. In three or four paragraphs, describe the falls today: How is it the same? How is it different? *(Even though Niagara Falls has moved a few miles closer to Lake Erie due to erosion, in many respects, the gorge and its thundering waters remain the same. Its surroundings, however, are a different story. There now are hydroelectric plants, factories, large buildings, and many tourists.)*

2. In the 1880s, people feared the rapid development of tourism and industry would ruin the scenic beauty of the area. They pleaded with government officials from both Canada and the United States to help. Around 1885, both countries established large park areas where factories and tourist hotels could not be built. The parks remain today. Pretend you are back in the 1880s. Are you for or against more commercial and industrial development? Take a stand, then write a letter to a government official in which you convincingly explain your position. *(Answers will vary, of course. Encourage students to be persuasive and to use proper letter-writing format.)*

3. Many groups of North American Indians enjoyed telling imaginative stories about nature such as why the bear has a short tail and why we have night and day. These tales are called *legends*. Write a legend about how Niagara Falls was formed. *(If students have difficulty with this assignment, read them a few tales from* The Long Tailed Bear and Other Indian Legends, *Natalia M. Belting, Bobbs Merrill, 1961.)*

Bibliography

Books about Niagara and other falls are difficult to locate. The best and most accessible information can be found in old *National Geographic* magazines. Show students how to use the Reader's Guide in their library. Then have them locate some of these magazine articles on waterfalls.

Because Niagara Falls is a tourist attraction, travel agents often have pamphlets on it. See if you can collect a few. They are always fun to read.

To find out more about hydroelectric power, read *Water Over the Dam* by Dorothy C. Hogner. Lippincott. 1960, grades 7-9. □

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Elephants' trunks and other nifty sniffers

Sandra Markle

This month we're going to investigate a topic that kids can really poke their noses into—elephants' trunks and other nifty sniffers! Included in this teaching unit are fascinating questions to discuss, activities that experiment with our sense of smell, and three challenging writing assignments.

Expand your study of noses by setting up a Natural Wonder Corner in your room, complete with reference books, pictures like the miniposter at left, and a few self-directed activities that invite students to become scent detectives. Here's one such activity: Cut squares from an old towel or sheet. Saturate each with a familiar scent: lemon juice, orange juice, apple juice, onion juice, ammonia, cinnamon, and so forth. Tuck each square into a separate baby food jar and seal with a lid. To examine each scent, your students should take off the lid and sniff. When everyone has had a chance to guess and wonder, you can reveal the scents.

Adorn your center with a bulletin board full of noses: a pig's snout, a rabbit's wiggly nose, an anteater's long nose, and more. Or encourage students to bring in pictures of famous noses: Snoopy's, Bob Hope's, President Reagan's, Karl Malden's, Barbra Streisand's, Miss Piggy's.

Does an elephant snore? You bet. And what a snore it makes through a nose that can be up to six feet long!

The baby giant in the picture at left is just getting the hang of what to do with its trunk. It takes six months for a baby elephant to learn to handle its nose well.

Actually a combination of upper lip and nose, the trunk is a super sniffer. With it, the elephant can sniff out food and water in several directions without even turning its head.

Elephants eat at least 16 hours a day, stopping only to find another lunch spot or to take a short nap, so a good sniffer is important. The elephant's trunk is also a good food gatherer. The soft, fingerlike projection on the end of the trunk lets the elephant pick up even small leaves or fruit as easily as you could with your fingers. Stretching its trunk high into a tree, an elephant can also collect food that shorter grazers miss.

In fact, in its hurry to pluck a mouthful, an elephant may rip off a big branch. But that's no problem for the elephant. Made up of more than 40,000 muscles, its trunk can lift a 600-pound load.

As you may have guessed, we're not talking about a lightweight eater. The elephant, which can be as tall as 11 feet and as heavy as 14,000 pounds, eats 300 to 600 pounds of vegetation a day.

An elephant is also a big drinker—30 to 40 gallons a day. Slurping up a gallon and a half in each sniff, the elephant squirts the water down its throat. Elephants love water. They use their trunks to spray it across their ears and backs to cool themselves. They even enjoy swimming. And when the water is deep, they use their trunks as snorkels. Good grooming for an elephant is a bath followed by a roll in the mud. This is finished off by a dusting of dirt which the elephant sprays over itself with its trunk.

An elephant's trunk is a hand, a hose, and a super sniffer. But it's more. An elephant trumpets, squeals, and screams through its nose. Fighting bulls (male elephants) lock trunks in a tug-of-war to pull each other off balance. Mother elephants caress their babies with their trunks. They correct a naughty child with a swift, noisy spank. A baby elephant follows the herd by gripping an adult's tail with its trunk. And when these giants really like each other, they twist their trunks together in a big elephant kiss.

Other nifty sniffers

Elephants are not the only animals with useful noses. Bats use their noses to help find their way through the dark by blowing great bursts of sound from them. The bat's sensitive ears pick up the echoes as they bounce back. Bats can nose in on a flying insect up to 15 feet away.

Then there's the shark. Its gills take care of supplying needed air. Its nose is strictly for smelling. Each nostril is lined with a smell-sensitive membrane. Messages pass directly from the nose to the brain. A shark can smell blood in the water one-fourth mile away.

The elephant, the bat, and the shark are just three of many animals with special noses. The activities that follow will explore these and other nifty sniffers more thoroughly.

Let's talk

Here are a few thought-provoking questions to discuss with students.

1. Moles are animals that live deep underground. The star-nosed mole has 22 fleshy tentacles forming a ring around its nostrils. The top middle two are held ridgedly forward. The rest wiggle constantly as the mole searches for insects to eat. Like the elephant, this animal has a very sensitive nose and an excellent sense of smell. Why is the mole's nose its most important sense organ? (Because moles live in the quiet, dark depths, they don't need a good sense of hearing or sight as much as they need a nose for sniffing and feeling their way around.)
2. Some ecologists think elephant herds should be thinned (some of the animals killed) yearly. They say that large herds are too destructive to the environment. Other ecologists say the herds should be left alone. Nature should be allowed to take its course. What do you think? (Answers will vary.)
3. An elephant uses its sense of smell to know if something is good to eat. How does your nose help protect you? (In general, food that is safe to eat smells good. Bad-smelling food such as spoiled meat is dangerous to put in your mouth.)

Let's investigate

1. Can you taste what you can't smell? Students can discover the answer for themselves. Give each student a paper plate with a tiny piece of apple and a tiny piece of onion. Ask them to close their eyes. Then tell them to turn the plates around

until they are no longer sure where the two pieces of food are located.

Now, have students pinch their noses and place one piece of food on their tongues. They'll find that without being able to smell, the foods won't have a very distinctive flavor—though they still can taste it. As a class, talk about how foods lack a lot of flavor when someone has a stuffed-up nose. Generally, we taste and smell food at about the same time.

Let's write

Below are three writing assignments kids will enjoy.

1. All dogs have better smell sensors than people do. Bloodhounds are the champs. And their sad-looking faces help them. Their droopy ears stir up scents from the ground. Their wrinkled skin traps the scents.

When a seven-year-old boy became lost in eastern Washington, a bloodhound was used to help find him. After sniffing an article of clothing that the boy had worn, the dog was able to follow the child's body scent. In less than a day, the bloodhound found the boy. Find out more about how dogs are used to find lost people. Write a newspaper account about one of these real dog-detective incidents. (Answers will vary.)

2. Read "The Elephant's Child" (*Just So Stories*, Doubleday, 1972) by Rudyard Kipling. Then make up a story of your own about how the elephant got such a long nose. (Answers will vary.)

3. What if your nose were as long and as useful as an elephant's trunk? Write a few paragraphs about the things you would enjoy being able to do with your nose. (Answers will vary.)

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Tornadoes and other big winds

Sandra Markle

Hold onto your hats! This month the Natural Wonder Notebook explores tornadoes and other big winds.

Set the stage for some gusty discussions by turning your Natural Wonder Corner into a multimedia storm center complete with tornado sound effects, maps, and moving pictures. Tape the song "Tornado Music" from the Broadway musical, The Wiz, *and the classical piece, "A Night on Bald Mountain" by Modest Petrovich Moussorgsky. Play these and ask students to explain how the music portrays a storm. (It builds, becomes faster, and grows more violent.) Challenge students to make flip books (a set of pictures that capture each movement of an activity) of a storm building and a tornado forming. (Most encyclopedias can provide model illustrations.) When the artwork is complete, replay the music as kids flip through their books. Now you have tornado movies!*

To decorate your corner this month, cover a bulletin board with a map of the United States, marking the states in Tornado Alley (Kansas, Iowa, Nebraska, Oklahoma, Missouri, South Dakota, and Minnesota) with small, black funnel clouds. Under the map, point an arrow toward the southwest corner of your classroom. This designates the direction most tornadoes come from.

Have each student cut a spiral (cut counterclockwise, the way real tornadoes whirl) from a piece of black construction paper. Then hang up these minitwisters and launch your own Operation Skywarn as you begin to investigate tornadoes and other big winds. (The real Operation Skywarn is a network of volunteers who watch for the appearance of a tornado after an official Tornado Watch is issued.)

And, of course, don't forget to post the colorful twister at left!

"Like the noise of 10,000 freight trains!" one eyewitness said. "Like the buzz of a million bees!" said another. Both persons were describing the sound of a tornado that had passed over their heads. Meteorologists (people who study the weather) believe that the sound a tornado makes is caused by the almost constant lightning that laces through the inside of the funnel cloud. Tornadoes are the smallest and yet the most destructive of all storms.

A tornado's funnel is rarely more than 350 yards across. (You could walk that distance in 350 long steps.) Some are no wider than a two-lane road. And when a tornado touches the ground, it lingers only a half minute before whirling on.

So what can a little piece of wind do in 30 seconds? A tornado can uproot trees, blow a house apart, carry away a bridge, throw cars across a parking lot, and perform a lot of other very destructive acts. These super storms have wind speeds measured at 150 to 300 mph and estimated (based on damage done) at up to 800 mph. There are many things about tornadoes that meteorologists don't know because these storms are too dangerous to study up close. But meteorologists do have a pretty good idea how tornadoes form.

When land or water is heated by the sun, the air above it is warmed. The warm air rises. (Watch the steam coming out of a teakettle.) Cooler air then rushes in to fill the space vacated by the warm air, and this moving cooler air becomes wind. The faster the warm air rises, the stronger the cool winds become.

Usually when a mass of hot, moist air meets a cold, dry mass of air, the cool air pushes under the warm air. But sometimes the cool air settles on top of the warm air, trapping it. The warm air struggles upward, and if a "tongue" of warm air breaks through, it cuts a tunnel into the cold air mass. Warm air quickly rushes in, forming a strong updraft. Now, still more air sweeps in from all sides to fill the spaces left vacant by the upward surging warm air. Partly due to the earth's own spinning and partly for reasons as yet unknown, a mesocyclone (a rotating column of air) forms. Soon the rising warm, moist air cools, and what once was water vapor changes into water droplets, forming a visible cloud around the updraft. This funnel-shaped cloud is pictured in the photograph at left.

Tornadoes form inside thunderstorms. The twisters usually move from the southwest to the northeast across the U.S. because this is the direction of the prevailing winds (general pattern of winds). Tornadoes rarely last longer than 20 minutes and seldom travel farther than 16 miles before they die. A tornado's path is usually a skipping course, touching down and then leaping on before touching down again. A record tornado did cut a path of destruction 293 miles long from Mattoon, Illinois, to the eastern boundary of Jennings County, Indiana, on May 26, 1917.

Wherever tornadoes reach the ground, they cause disaster. In a 24-hour period on April 3 and 4 in 1974, 148 tornadoes struck 13 states and parts of Canada. This was a record outbreak with a death toll of 315 people. Hardest hit was Xenia, Ohio, which lost two percent of its population and had whole sections of houses and buildings leveled.

Many tornado-related deaths are caused by collapsing buildings. Besides the terrible force of the wind, the rapid rush of air into the funnel creates a partial vacuum around the tornado. The sudden removal of the equalizing pressure of air on the outside of a building makes the air inside the building push out. The building then explodes.

Tornadoes are a worldwide wonder, but the U.S. has the most twisters of any country—more than 620 a year. The majority of them strike the central states between the Rocky Mountains and the Appalachian Mountains. Called Tornado Alley, this region is a battleground where warm, moist air from the Gulf of Mexico and cold, dry air from Canada meet head on. April, May, and June are the months when these air masses are the most different and therefore most likely to generate tornadoes.

Fortunately, the death toll from tornadoes has decreased sharply since the late

1950s. This decline is mainly due to the development of new storm detection techniques (weather satellites and improved radar) and to the creation of the National Severe Storm Forecast Center. This center is located in Kansas City, Missouri—right in the middle of Tornado Alley. Operation Skywarn, a national network of local volunteers, also plays an important role in tornado detection because tornadoes can appear suddenly and without warning, despite the many efforts to forecast their approach.

Forecasters issue different kinds of tornado bulletins. When they issue a Tornado Watch, it simply means that conditions are right for a tornado to form. People should proceed as usual but stay tuned for updated reports. When a Tornado Alert is issued, that means a tornado has been spotted, and anyone within the storm's projected path should take immediate safety precautions. If you are out walking when you are warned of a Tornado Alert, you should go to the nearest steel and concrete building (always remain away from windows). If a building isn't close, lie down in a ditch and cover your head. At home, you should go to the basement and get under a heavy table. If you don't have a basement, move to the center of the house and take shelter under heavy furniture. At school, you should move to interior halls on the building's lowest level. If you're in a car, the driver should drive away from the storm. (Always move away from a tornado in right angles to allow for the twister's curved path.) Or if the storm is very close, you should leave the car and lie down in a ditch with your head covered.

Tornadoes will never become less dangerous. But thanks to high-power technology and dedicated storm watchers, we are better able to protect ourselves from these super winds than ever before.

Other big winds

Tornadoes are not the only winds that cause problems. Hurricanes have winds that average 100-175 mph and are the largest storms in the world. Hurricanes can be hundreds of miles wide, travel thousands of miles, and last more than a week before they die. These storm giants form over the oceans near the equator and spiral toward land. Brave hurricane hunters fly into these storms to gather information about wind speeds and direction and to map the size of the storm.

And then there are blizzards. Blizzards are winter storms that happen when super cold, polar air crashes into warm air that is full of water vapor. As the polar air shoves the warm air up into cooler temperatures, the water vapor freezes and becomes snow. Fierce winds and very cold temperatures come with the snow. In the winter of 1976-77, blizzards brought snow to southern states unaccustomed to winter storms. Heavy snowfalls in northern states left communities isolated, without power and without heat until the storm had ended and people could begin to dig out.

Tornadoes, hurricanes, and blizzards are just three kinds of winds. The activities that follow will explore these and other winds more thoroughly.

Let's talk

Share these discussion starters with the class.

1. When the ground overheats, the layer of air above it gets warm and rises rapidly. Cooler air rushing in to fill this space often forms a whirlwind (a minitornado). Whirlwinds and dust devils (dust whirled by the whirlwinds) are most frequent in deserts, but dust devils are also common in big cities. Why? (Cement- and pavement-covered areas collect heat, then radiate it into the air. Tall buildings channel the rising air upward, creating a strong updraft as cool air rushes in underneath the rising warm air. Dust from construction is whirled in this updraft.)
2. Project Stormfury, under the control of the National Oceanic and Atmospheric Administration, was set up to study ways to stop hurricanes. These scientists would like to try out their ideas, some of which involve seeding and exploding clouds. So far they have been allowed to experiment only on a very few hurricanes that were far out at sea. People are afraid that such experimentation may, in fact, make the storms worse. Do you think scientists should be allowed to experiment with hurricanes? (Answers will vary.)

Let's investigate

1. Students can see for themselves that air rises when it's heated. Use an electric skillet as a heat source. Place a glass pop bottle (one without cracks) in the skillet. Cover the top of the bottle with the neck of a large rubber balloon. Pour enough water into the skillet to cover the bottom, and turn the skillet on medium heat. Be prepared to add more water as needed.

As the air in the bottle heats, students will see the balloon fill and lift. Now, have the class predict what will happen as the air in the bottle cools. Cool air sinks. Watching the cooling bottle will prove this and show why cold air masses usually move under warm air masses.

2. To demonstrate why tornadoes make buildings collapse, place an empty, well-washed metal can (the kind duplicating fluid comes in) in the electric skillet. Remove the cap. Pour enough water into the skillet to cover the pan bottom. Heat on medium heat for 20 minutes, adding more water as needed. Quickly screw the cap onto the can. Use a potholder to remove the can from the heat.

Tell your students that heating caused the air in the can to rise and escape through the opening; capping the can prevented enough cooler air from rushing in to fill the can. There is now a partial vacuum in the can. As your students watch, the can will begin to collapse. This is the reverse of what happens to buildings during a tornado. The air around the can is pressing in (15 pounds per square inch). In a building, the air is pressing out.

(Note: These two investigations are designed for teachers to perform only.)

Let's write

Here are two writing assignments students will enjoy.

1. Members of the U.S. Air Force's Weather Reconnaissance Squadrons are hurricane hunters. Do a little research on these operations. Then pretend you are a hurricane hunter and write a diary account of a flight into a hurricane.
2. Use the index for a major newspaper such as the *New York Times* or the *Chicago Tribune* to look up articles about tomadoes. Two recent major outbreaks are the ones occurring on April 3-4, 1974 and the Palm Sunday outbreak on April 11-12, 1965. Then write your own fictional account of a tornado outbreak.

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The Grand Canyon
and other holes in the ground

Sandra Markle

Visited by more than three million tourists annually, the Grand Canyon is the natural wonder people most want to see in the United States. This month's Natural Wonder Notebook features not one, but three Grand Canyon adventures: one on foot, one by burro, and one by boat. Each pretend trip offers a different perspective of a truly grand canyon.

Turn your Natural Wonder Corner into expedition headquarters by displaying a large map of the area. Using the map on the following page as a model, mark the origins of the first two journeys, which are down canyon walls. Use two different colors of ink. In a third color, trace the entire route of the last journey, along the Colorado River. Hang up pictures of the canyon, including the miniposter at left, and stock your corner with books on wilderness survival and canyon expeditions. (See bibliography.)

A canyon is a valley with two steep sides. The Grand Canyon extends 277 miles in northwest Arizona, is more than a mile deep, and ranges from 2 to 18 miles wide. The Colorado River flows through its valley.

Millions of years ago the entire area was a flat plain, situated just above sea level, and the Colorado River was a meandering stream. Then, active forces inside the earth uplifted the plain and sent the Colorado River rushing toward the sea. As the river grew larger and more powerful, it picked up heavy loads of gravel, silt, and sand, which scoured a deep path through the canyon. Down, down the Colorado River sliced, uncovering layers of rock that had been deposited by water and wind millions and even billions of years earlier. You'll have a chance to explore these layers of rock carefully on the first Grand Canyon adventure—the trip on foot.

On foot This two-day trip requires the most endurance and preparation of the three adventures. You'll want to wear comfortable shoes and clothing that can be shed or added in layers as needed. Park rangers recommend that each person carry two gallons of drinking water and enough food for five meals, including a supply of high-energy food like nuts and raisins.

Find Kaibab Trail on your Natural Wonder map. It is located on the north side of the canyon (8,000 feet above sea level). This is where your hike begins. The trail is approximately 21 miles. On the first day, you'll climb down the north wall from rim to river. At the bottom of the canyon is Phantom Ranch, where you can rent a cabin for the night. The next day you'll climb up the south wall and out of the canyon. This hike is ideal for exploring the Grand Canyon's many layers of rock. (See illustration on this page.)

As your trip begins, you'll notice that a thin coat of topsoil covers the north rim. Below this lie the Kaibab and Toroweap limestone formations, which are about 225 million years old—young compared to lower formations. Look for fossils (remnants or impressions left by plants and animals) in these limestone layers. Imprints of tri-lobites, sharks, corals, and shellfish are frequently found. But those are *sea* creatures, you say! Well, like the older limestone formations you'll encounter further down, Kaibab and Toroweap prove that this area was covered by ocean at various times.

The next layer you reach is Coconino Sandstone. It's about 300 feet thick and indicates that the Grand Canyon was once a desert. Coconino was the top layer of rock. (Sandstone is formed by compressing sand dunes.) Look for fossils of scorpions, spiders, and small desert reptiles here.

Your next stop is Hermit Shale. Shale layers record periods millions of years ago when mighty rivers dumped sediment over the Grand Canyon area. Careful inspection of the shale can sometimes reveal animal tracks.

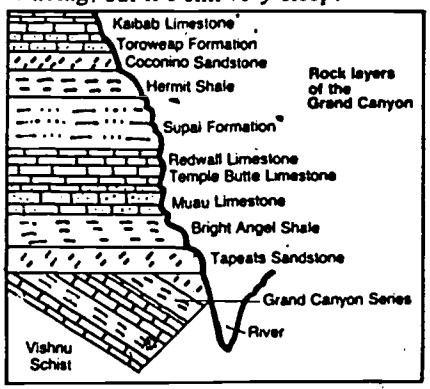
Descending further, you reach several layers of limestone (Supai Formation, Redwall Limestone, Temple Butte Limestone, and Muav Limestone) and then Tapeats Sandstone.

The tilted layers below the Tapeats Sandstone formation are called the Grand Canyon Series. This rock formation is half a billion years old and represents a time when the land was uplifted, broken into mountains, and then eroded flat. The only fossil record of life in this formation is algae, a primitive plant related to seaweed.

The basement rocks are worth the entire walk. Called Vishnu Schist, these medium- and coarse-grained black rocks are estimated to be 1.3 billion years old—some of the oldest rocks visible on earth. There is no evidence of life shown in this formation, but then these rocks have been greatly changed by pressure from the many rock layers resting above them and from heat within the earth's crust.

You've made it! You've reached the bottom of the Grand Canyon. Look up at the rim of the canyon: that's one mile up! Enjoy the valley, the view, and your stay at Phantom Ranch, but don't linger long. The forces that carved this deep canyon are still at work. In a million years or so, the climb up the south rim will be much higher!

By burro Find Bright Angel Trail on the expedition map. Located on the south rim, the narrow, winding trail descends for eight miles into Granite Gorge. You'll follow it to the canyon floor and back. Mount your burro, hang onto the saddle horn, and enjoy the view as your surefooted pack animal plods along the rocky trail—but don't lean over too far. The trail may be winding, but it's still *very* steep!



As you look across the canyon, you see rounded rock formations. Some look like giant stepping-stones; others resemble stone towers and fanciful sculptures. These shapes are the result of a process called *differential erosion:* softer rock particles are carried away by erosion while more resistant rock remains.

Four eroding forces are at work in the Grand Canyon: running water, frost, wind, and gravity. The running water comes from rainwater, streams, and the Colorado River. As it rushes down or through the canyon, its powerful force loosens rock and carries it away. Some of the water seeps into the rock cracks. When this water freezes, it expands, breaking still more rock chunks loose. Strong winds carrying fine sand blast away other rock particles. Then gravity adds its eroding force by pulling down on jutting ledges until they collapse.

The plant life you see along the trail is as varied as the rock sculptures. At the higher altitudes there is lush vegetation, but as you descend, cactus and yucca appear. That's because the rims of the canyon receive 16-26 inches of rainfall a year, while the canyon floor receives less than 10 inches yearly.

The amount of sunlight that filters into the canyon also affects plant growth. The south wall, which you are traveling on, is usually in shadow. Therefore, it supports trees that need less light like juniper and pinon. The sunny north rim of the canyon is covered with aspen, fir, and spruce trees.

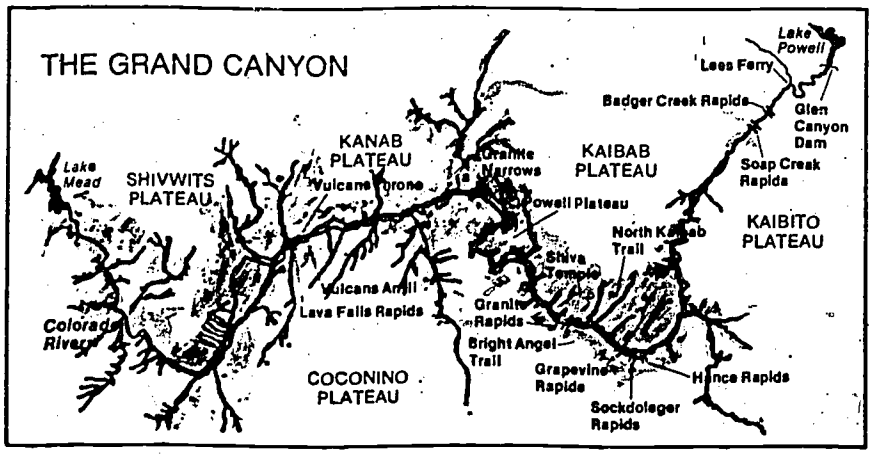
The canyon is home to 275 species of birds and about 120 other kinds of animals. Look for beavers, big-horn sheep, elk, lizards, mountain lions, mule deer, antelope, and snakes. Like the plants, the animals have settled where the climate suits their needs. Some like the mule deer range from rim to river. Others like the white-tailed Kaibab squirrel are found only in one place—in this case, the ponderosa pine forest on the north rim. These squirrels, as well as pink rattlesnakes, exist only in the Grand Canyon.

The American Museum of Natural History mounted an expedition in 1937 to search this general area for isolated animal communities. The project was followed with a lot of excitement as people imagined all sorts of strange creatures living in the Grand Canyon. One newspaper even suggested dinosaurs. No new animal species were found, but don't let that stop you from imagining what secrets the canyon may hold as you complete your day-long burro trip.

By boat Find Lees Ferry on the map. That's the starting point for your last expedition. Lees Ferry was the spot where pioneers crossed the Colorado River. It's also where, in 1869, John Wesley Powell led 10 men on the very first boat trip through the Grand Canyon.

You are going to board a dory here. The dory, a flat-bottomed boat with high flaring sides, will take you just past Lava Falls. Depending on the weather, it will take you about 18 days to make this 150-mile trip. From the start, the roar of the water is almost deafening, particularly as you approach Badger Creek and Soap Creek Rapids. These rapids are followed by Hance Rapids, Sockdolger Rapids, and Grapevine Rapids. Rapids are areas in a river where the current is fast and the river's surface is broken by obstructions like fallen trees and rocks. Proceed with caution through these areas. One of Powell's four boats was shattered against the rocks by rapids.

Look to the left and soon you can spot Bright Angel Trail, where you took your burro ride. Then on to more rapids and finally, to Vulcan's Throne and Lava Falls.



Black lava from an old volcano covers the canyon walls in this area and rises in cone-shaped figurations (forming a throne) above the north rim. It is called Vulcan's Throne after Vulcan, known as the blacksmith of the Roman gods. Shafts of jagged lava (some more than 100 feet high) rise from the river bed, helping to form treacherous rapids. Just beyond Vulcan's Throne is Lava Falls, an area of fierce rapids where the river drops 37 feet in 80 yards. There is no way to portage (carry the boat around) this falls. The only way forward is to go with the river.

It took Powell's group three months to reach this point. When the 10 explorers saw Lava Falls, three elected to climb up and out of the canyon and begged the others to come with them. Refusing to give up, Powell and the remaining members climbed into two boats and launched themselves into the rapids. Today, Lava Falls still has some of the most powerful navigable rapids in the world.

Powell's group reached calm water safely and so will your expedition. In fact, your trip through the canyon is less dangerous than the journeys Powell and later explorers faced. Glen Canyon Dam now controls the amount of water rushing through the canyon. The flow may vary from 30,000 cubic feet per second to as low as 990 cubic feet per second—a mere trickle.

Other canyons

Canyons form some of the most breath-taking scenery in North America. Students may wish to investigate Royal Gorge, a canyon in Colorado that supports the highest suspension bridge; the deep canyons and thunderous waterfalls formed by Yellowstone River in Wyoming; or the beautiful smaller canyons located throughout the Canadian Rockies. There are also many underwater canyons called *submarine canyons*. These are found on coastal shelf off the mouth of large rivers. One of the largest is at the mouth of the Hudson River in New York.

Let's talk

Ponder these questions with your students.

1. Bryce Canyon in southern Utah was formed mainly by the eroding forces of wind and rain rather than by the carving force of a river like the Colorado. Bryce Canyon is noted for its sharp, exotic rock spires and fragile-looking shapes. Why do you think this canyon's formations are more

delicate and pointed than the ones found in the Grand Canyon? (The washing, grinding force of the Colorado River rounded off the Grand Canyon's landscape.)

2. When Ebenezer Bryce, a farmer and Bryce Canyon's namesake, was asked what it was like to live in Bryce Canyon, he replied, "It's a tough place to lose a cow." What other humorous descriptions might apply to living in a large canyon? (Answers will vary.)

Let's investigate

Students can see how differential erosion works by placing several large rocks in a bucket and then packing sand around and over the rocks. Gradually pour water (the eroding force) onto the mound. Loose sand grains will wash down to the bottom of the bucket. Stop frequently to see how the rock formation is changing. More tightly packed sand and the buried rocks resist the water's eroding action.

Let's Write

Try these writing assignments with students.

1. According to American Indian legend, the Grand Canyon was formed when a god hit the earth with a giant ax. Another tale credits Paul Bunyan with the deed. The story says Paul carelessly dragged a heavy *peavey* (hook for moving logs) behind him as he strolled along. The sharp hook dug through the ground creating the deep canyon. Make up your own tall tale to explain how the Grand Canyon was formed.

2. Imagine yourself on John Wesley Powell's first expedition through the Grand Canyon. The group was gone so long that newspapers reported it lost. Write a letter home, telling your family that you've made it safely out of the Grand Canyon and that Powell's expedition was a success. Then tell them about the most challenging experiences of your trip.

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